SPORTS SPECIFIC TRAINING METHOD AND APPARATUS

The present application is a continuation-in-part of U.S. Patent Serial No. 09/435,220, entitled "Run Specific Training Method and Apparatus," filed November 5, 1999.

Field of the Invention

The present invention is directed to a method and apparatus for isolating a joint of an athlete from other joints in the body and training the isolated joint using sports specific, supra-maximal techniques designed to achieve both maximum acceleration and a minimum stretch-shortening cycle.

Background of the Invention

By increasing intensity and duration, performance of an athlete will improve up to a point. Continued training above and beyond an optimal level will produce a subsequent decline in performance due to mental and physical breakdown. This phenomenon is known as the overtraining syndrome. Therefore, if an athlete is following state of the art training philosophy and methods and is training at the threshold of overtraining, performance can only improve if the training program is improved.

Since about 1970 a multitude of exercise machines have been developed with a wide variety of resistance mechanisms, including isotonic, isokinetic, pneumatic, hydraulic resistance and elastic resistance mechanisms. These machines typically are adapted to train one aspect of performance, such as acceleration or stretch-shortening. The prior art, however, fails to teach a device with adequate joint isolation adapted to train for stretch-shortening, acceleration, or

both.

Acceleration training, for example, is best developed by a hydraulic resistance mechanism (pneumatic resistance being similar but less preferred due to a bounce effect at the start of a "lift"). Pneumatic devices that include a separate device for each individual joint are available from Keiser Corp. The Keiser pneumatic devices include a pump, which gives them the capability for both concentric and eccentric training.

Some hydraulic resistance exercise devices allow for both concentric and eccentric training. Most, however, give purely passive resistance, which allows for only concentric training. Some hydraulic apparatuses have been developed for cardiovascular conditioning, such as disclosed in U.S. Pat. Nos. 5,180,353 and 5,527,251.

Various weight loaded training apparatuses are available, but generally lack adequate stabilization of the surrounding body parts. The neck muscles can be trained on devices as describe in U.S. Pat. No. 4,066,259. U.S. Pat. No. 5,3366,138 discloses stabilization and isolation of the neck using a 2-point fixation system.

U.S. Pat. Nos. 4,725,055; 4,725,0566 and 4,836,536 disclose trunk-strengthening devices for exercising abdominal flexors and/or back extensors. These devices lack adequate stabilization and isolation of the abdominal muscles. The point of fixation below the abdomen for that patent is the thigh, which means that the hip flexors are trained along with the abdominal muscles.

Shoulder exercise devices include linear and rotating type mechanisms. Linear mechanisms are disclosed in U.S. Pat. Nos. 4,195,834; D302,713 and 5,931,767. Rotating devices are disclosed in U.S. Pat. Nos. 4,569,519; 4,757,992; D321,387; 5,180,354; and 5,803,882. Elbow exercisers includes flexion (biceps) and extension (triceps) strengthening devices are disclosed in U.S. Pat. Nos. 5,256,125; 5,897,467; and 5,350,345. None of these patents

disclose an adequate 3-point fixation system.

U.S. Pat. Nos. 4,247,098 and 5,273,508 disclose hip strengthening devices. Some hip exercise devices derive stability by placing the athlete in a recumbent position (lateral, prone or supine, depending on the manufacturer), as disclosed in U.S. Pat. Nos. 4,200,279; 4,247,098; and 5,273,508. These devices, however, do not train the athlete in an upright manner, which would simulate a more functional and more sport specific position for the majority of athletic events. Moreover, these devices lack a fixation system adequate for isolating the desired muscles.

U.S. Pat. Nos. 4,247,098 discloses only a 2-point fixation system to secure the athlete. The stretch-shortening cycle cannot be trained because there is no eccentric component in this resistance device. Although some acceleration can be trained by virtue of a hydraulic resistance device, there is no adjustable resistance mechanism as the hydraulic device here is simply a "shock-absorber" apparatus. U.S. Pat. No. 5,273,508 specifically includes use of the lower back and abdominal muscles during training of the hip, and hence, does not isolate the desired muscles. U.S. Pat. No. 4,200,279 discloses no hip flexor training capabilities. U.S. Pat. No. 5,273,508 discloses some hip flexor strengthening capabilities, but it does not allow for single-leg training, nor does it isolate the hip muscle. Finally, these devices do not train the lower hamstring muscles, which are also important for hip extension.

Various upright hip exercising machines have been developed, such as disclosed in U.S. Pat. Nos. 4,600,189; 4,621,807; 4,711,448; 4,732,379; 5,067,708; 5,308,304; 5,354,252; 5,468,202. The main limitations of these devices are that they do not adequately stabilize the trunk of the athlete to permit isolation of the target muscles. The device disclosed in U.S. Pat. No. 4,732,379 discloses an isokinetic resistance hip exercising/ testing device with a trunk pad. However, stabilization is limited to an inadequate 2-point fixation system. The other patents disclose purely isotonic exercisers using a weight stack, and hence cannot adequately provide

acceleration training. Another problem with these devices is limited vertical adjustment capabilities, which is important to properly center the hip joint during exercising for sports specific training. While the device disclosed in U.S. Pat. No. 5,067,708 has multiple vertical adjustments at the actuator, this device provides no trunk stability. Finally, the athlete is not able to train the lower hamstrings for hip extension with these devices.

U.S. Patent No. 4,357,010 (Telle) discloses a hydraulic device where the rate of movement of the bars during lifting of the weights is maintained substantially constant by an 'isokinetic device' connected between the structure and one of the beams. The Telle device uses the hydraulic device for an isokinetic (constant speed) function to control momentum of the weights and to maintain constant velocity. Constant velocity is a sub-optimal method of training for acceleration. Telle also teaches that weights are needed to control the malingering factor that may occur when training on solely isokinetic equipment. This teaching strongly suggests that the Telle device is mainly an isotonic training apparatus, where the hydraulic/isokinetic unit is used in conjunction with the weights to maintain constant velocity, but not alone. Additionally, the hydraulic unit of Telle is not detachable. When training stretch-shortening isotonically, the inherent friction in the hydraulic unit, even if the resistance is set at zero, lessens the eccentric load and gives sub-optimal stretch-shortening training. The device of Telle is intended to allow the performance of multiple exercises on one device, rather than for isolated joint training. Stabilization of a particular joint is not discussed. Finally, because the way in which the hydraulic unit is attached to the actuator arm (perpendicular to it), only linear types of (multiple joint) exercises are possible, not single joint rotating exercises.

Knee flexion (hamstrings) and extension (quadriceps) training devices are disclosed in U.S. Pat. Nos. 4, 502, 681; 4,732,380; 4,776,587; 5,050,589; 5,116,296. U.S. Pat. Nos. 4,502,681 and 4,776,587 use a distal thigh strap for knee

stabilization, which is inadequate because optimal stabilization of the thigh for quadriceps strengthening should be at the proximal thigh near the hip joint. U.S. Pat. Nos. 4,732,380 and 5,116,296, which are indicated for both quadriceps and hamstrings muscle training, use a mid thigh pad, which is inadequate for either of those muscles. U.S. Pat. No. 5,050,589 is a prone hamstrings training apparatus, which uses a thigh strap to stabilize it for performing hamstrings exercises. Again, adequate hamstring training requires proximal stabilization at the buttock, not at the mid-thigh, thus this stabilization is inadequate.

With regards to knee flexion (hamstrings) exercising apparatuses, there are several variations, including upright sitting, vertical standing and prone or supine lying devices. Vertical or standing hamstrings training devices disclosed in U.S. Pat. Nos. 4,322,071 and 4,358,108 demonstrate 2-point systems. The prone or supine devices disclosed in U.S. Pat. Nos. 4,509,746; 4,696,469; 4,732,380; 5,050,589; D 321,391 and 5,066,003 for hamstrings lack adequate 3-point stability. An ankle exercising apparatus is described in U.S. Pat. No. 5,352,185, but no 3-point stabilization is disclosed.

In summary, the prior art lacks an exercise device with an adequate 3-point fixation system with a combined hydraulic power trainer and isotonic stretch shortening trainer suitable for practicing the method of training for both power and acceleration on a single device.

Summary of the Invention

The present training method and apparatus provides resistance to train for acceleration and the stretch-shortening cycle through a range of motion that simulates a particular sport or motion of a particular sport. The joint is isolated using a three contact point isolation and stabilization system. The isolated joint is trained using supra-maximal techniques designed to achieve both maximum acceleration and a minimum stretch-shortening cycle.

Sport specific training or a sports specific motion refers to actually engaging in the sport or exercising in a way that mimics the motion and muscle functions that occur during participation of a particular sport. For example, sports specific training for runners refers to a stride appropriate for the distance of the running event or a motion that simulates the stride. For baseball players, the sports specific training may involve a throwing motion.

Acceleration training refers to accelerating the portion of the body being trained in a sports specific motion as fast as possible in the early lift cycle and relaxing slightly on the return stroke. Although hydraulic resistance is preferred to train for acceleration, isometric, isokinetic, isotonic, pneumatic, or elastic resistance may also be used.

Stretch-shortening cycle training refers to allowing a weight to fall as rapidly as possible on the down stroke, focusing on stopping this motion when the starting position is reached, and with as much force as possible, converting the downward momentum of the weights to an upward direction. The stretch-shortening cycle can be trained using a cable-pulley-weight stack system, direct drive weight stacks, plate loading devices, motorized hydraulic/pneumatic devices and elastic devices such as elastic bands, coil springs, bending poles, and various other systems may be used.

Supramaximal training (or overload training) refers to exercising with loads beyond those normally incurred when engaged in the sport. Supramaximal training requires substantially complete isolation and focus on the muscle or action being trained. The stretch-shortening cycle refers to the rapid conversion of an eccentric to concentric muscle contraction (and visa versa) such as which occurs when the hip is fully flexed and then begins to extend.

Isotonic training involves moving a weight through an arc of motion. The momentum of the weight once in motion reduces the resistance. Isokinetic training involves moving a lever arm at a constant angular velocity. Resistance is

only provided at the preset velocity. Consequently, both isotonic and isokinetic training are sub-optimal methods of training for strength and acceleration. Hydraulic training provides resistance at all velocities through the entire range of motion. While hydraulic training is useful for developing strength and acceleration, it is a sub-optimal methods for training the stretch-shorting cycle (the rapid conversion of an eccentric to concentric muscle contraction such as occurs when the hip is fully flexed and then begins to extend).

As used herein, isotonic resistance refers to exercising with a constant load, the simplest example being lifting weights. Due to mechanical advantage through different arcs or motion, the resistance to the user is not always constant even though the load is constant. In fact, the most common weight lifting apparatuses use variable-resistance isotonic loading. These include cable-pulley-weight stack devices, direct drive weight stack devices and plate loading systems where mechanical advantages and disadvantages are built into the systems by use of cams to provide variable resistance through the range of motion. Other examples of isotonic resistance mechanism include a weight stack with a cable and pulley mechanism, a direct drive weight stack, a plate loading device, motorized pneumatic or hydraulic resistance devices, and elastic resistance mechanisms. Hydraulic resistance refers to resistance that varies with the force applied.

In one embodiment, the resistance for training acceleration is hydraulic and the resistance for training the stretch-shortening cycle is isotonic. The combination hydraulic and isotonic resistance allows an athlete to change from completely hydraulic or completely isotonic training or any combination of the two simultaneously. The hydraulic resistance device preferably consists of either a double-acting cylinder or rotary hydraulic actuator having a control valve that permits the user to vary the resistance settings providing for a workout with varying degrees of maximum speed and acceleration. The valve may have either a set number of resistance settings or an infinite number of settings.

Various weight loading mechanisms are the preferred method for training the stretch shortening cycle. The preferred type of weight loading mechanism is a plate loading system, although any number of weight stack or weight plate designs may be used. Alternatively, an electric or motorized pneumatic, hydraulic or isokinetic device capable of converting an eccentric contraction to a concentric contraction in accordance with plyometric training principles may be used.

An hydraulic and a weight loading mechanisms are preferably both attached to each individual training apparatus. Combining the hydraulic and the weight loading apparatus on single device saves cost, space and is easier to use than two separate mechanisms. In another embodiment, a small weight can be attached to the hydraulic unit so that the return stroke is returned to the starting position without the athlete having to expend any effort.

An adjustment mechanism is provided to adjust the axis of rotation of the athlete's joint to the center of the axis of rotation of the resistance mechanism, and therefore, best simulate a sports specific motion. Electronic components can optionally be included for biofeedback to measure force production, rate of force production, maximum rate of limb motion, range of limb motion, time to peak force (acceleration), etc. Data may be stored on a computer to allow the user to follow his progress in future workouts. It would also display progress for those undergoing rehabilitation from, *i.e.*, an injury or surgery.

The present invention is also directed to various devices that isolate individual joints (wrist, elbow, shoulder, ankle, knee and hip) and spine segments (trunk or neck) and provides the ability to train for acceleration (power) and stretch shortening (plyometric) training through a sports specific motion.

The piston from the hydraulic resistance unit may be attached in any one of several ways: (1) to the actuator arm on the same side as the user for linear types of exercises in either the compression or the tension mode; (2) to the actuator

arm on the opposite side of the axis of rotation, for a linear type of exercise, in either the compression or the tension mode; (3) in line with movement of a limb for exercising an isolated joint, rotating type of exercise in either the compression or the tension mode; (4) to a lever extending from the rotating actuator axle in either the compression or the tension mode; (5) to a weight stack or weight plate mechanism in either series or parallel alignment; or (6) the use of a circular, or rotating, hydraulic actuator may be used. The present invention contemplates attaching a hydraulic resistance device to any existing weight loading apparatus using one of the six mechanisms discussed above. The hydraulic unit has the capability of being completely detached from the weight loading mechanism such that either resistance mechanism could be used separately. Specifically, (this is most important when the eccentric load of the stretch shortening cycle is being trained) this configuration is to avoid any friction on the down stroke of the weight lift, which acts to slow down this motion and lead to a less than optimal training load.

Brief Description of the Several Views of the Drawing

Figures 1A and 1B are schematic illustrations of a wrist stabilization system in accordance with the present invention.

Figures 1C and 1D are schematic illustrations of an upper arm stabilization system in accordance with the present invention.

Figures 2A and 2B are schematic illustrations of a shoulder stabilization system in accordance with the present invention.

Figures 3A and 3B are schematic illustrations of an ankle stabilization system in accordance with the present invention.

Figures 4A and 4B are schematic illustrations of a knee stabilization system in the sitting position in accordance with the present invention.

Figures 4C and 4D are schematic illustrations of a knee stabilization system in the standing position in accordance with the present invention.

Figures 4E through 4H are schematic illustrations of a hip stabilization system in accordance with the present invention.

Figures 5A and 5B are schematic illustrations of a neck stabilization system in the sitting position in accordance with the present invention.

Figures 6A through 6D are schematic illustrations of an abdominal stabilization system in accordance with the present invention.

Figures 7A through 7F are schematic illustrations of various actuator configurations using a hydraulic resistance device in accordance with the present invention.

Figures 8 through 13 are perspective views of an exemplary hip training device in accordance with the present invention.

Figure 14 is a schematic illustration of an alternate isolation system in accordance with the present invention.

Figure 15 is a schematic illustration of an alternate isolation system for a semi-prone position.

Figures 16 and 17 are schematic illustration of a sectorized weight stack used for knee extension and flexion.

Detailed Description of the Invention

The present invention is directed to an exercise method and apparatus for athletes, that when added to current training techniques will improve performance. Most sport activities consist of a series or sequence of joint and muscle actions. The present method involves breaking down and training the actions of each joint in the sport cycle.

It is well established that strengthening or resistance exercises are an important part of any athlete's training regimen. Sport specific training is the optimal way to train for a specific sport or activity in a sport. Sport specific training involves training muscles in such a way that mimics their function during the target

activity.

In order to continue improving, the athlete needs to follow overload, or supramaximal training principles. This techniques involves stressing muscles which are involved in a certain activity above and beyond the demands normally placed on them during the target event. To obtain optimal benefit from supramaximal training, muscles and/or body movements must be isolated. Furthermore, in order to completely isolate a muscle or function requires that the surrounding body parts be completely stabilized. Only when isolated and fully stabilized can the athlete place maximum focus on the target muscle.

With respect to sport specific motion, limbs as a rule don't move at constant velocity. Muscles acting at a joint cause an acceleration of the respective limb, which is followed by a deceleration. The acceleration is caused by what is called a concentric contraction. In a concentric contraction the muscle shortens when it contracts. The deceleration is accomplished by an eccentric contraction. Here the muscle lengthens as it contracts.

Eccentric contractions are associated with injuries such as tendonitis, muscle pulls and tears. When a muscle contracts, internal structures within a muscle cell shorten. If an entire muscle belly (external structure) is lengthening, as in an eccentric contraction, and at the same time the internal structures are shortening, it creates opposing forces between internal and external structures. This push-pull antagonism, if excessive, overloads the system and can thus lead to injury.

During most sporting events muscles don't simply undergo isolated concentric or eccentric contractions. Although the onset of a motion is due to a concentric contraction, which causes acceleration of a limb, most events (*i.e.*, running, throwing) consist of a series of repeating concentric, eccentric, concentric, eccentric contractions. When the limb completes one of these eccentric contractions in the series and slowly converts to a concentric one, tension generated by the eccentric contraction is dissipated as heat. If, on the other hand, this conversion

occurs rapidly, as for most sporting events, then a significant amount of the tension developed during the eccentric contraction is stored as energy, which is released in the subsequent concentric contraction. The total maximum force that can be developed by this concentric contraction is much greater than when the concentric contraction occurs alone. The rapid eccentric — concentric conversion is referred to as a stretch shortening or when repeated is referred to as the stretch shortening cycle.

Since functional activities in sports involve acceleration of a limb and stretch shortening, sports specific training requires that these two types of contractions be focused on during the training period.

Acceleration training may also be called power training. Power training refers to generating force as fast as possible. Time to peak force is more important than the absolute force generated. Power training can be accomplished by any one of a number of strength training techniques including isometric, isokinetic, isotonic, pneumatic, hydraulic, elastic, etc. Hydraulic resistance is felt to be the optimal way to train for acceleration of a limb. The other strength training techniques have limitations. Isometrics is not very specific as there is no actual limb motion. It is difficult to adapt isometrics to sports specific exercises. Isokinetic training is not physiologic because, by definition, it consists of a constant velocity, rather than the acceleration that is preferred. Resistance is provided when a preset velocity is reached, thus isokinetic systems provide no resistance at the onset of a contraction or when fatigue sets in. In addition, isokinetic systems tend to be very expensive and have found a niche in the rehabilitation arena rather than in the gym. Finally, while isotonic and elastic resistance mechanisms can be used to power train, both involve concentric and eccentric contractions, thus full focus on concentric acceleration is not possible.

Hydraulic resistance is believed to be the optimal method for acceleration training for a variety of reasons. First, it is purely concentric, which is important in being specific to the muscle's needs and also being safe and useful if

there is an injury. Second, the resistance setting can be varied and is active throughout the arc of motion. The resistance once set, still varies to the athlete's effort, (it is accommodating) and allows the limb to accelerate at different rates. Fatigue does not exclude resistance. Finally, hydraulic mechanisms are cost competitive. Pneumatic devices are similar to hydraulic ones in that resistance is set by adjusting the flow of air, as opposed to fluid, through an aperture. Because air is compressible there is a certain bounce effect at the onset of contraction with pneumatic mechanisms thus they are less preferable than hydraulic ones.

The athlete also needs to train the stretch shortening cycle. A more recognized term for stretch shortening training is plyometrics. Plyometric exercises involve rapid deceleration of a mass followed almost immediately by a rapid acceleration of the mass in the opposite direction. The benefits of plyometrics are well documented in the literature and a well accepted training method amongst coaches, trainers and athletes. Commonly used plyometric exercises for the lower extremities include vertical leaps (both single and double-legged), tuck jumps, horizontal bounds (both single and double-legged), box jumps, cone jumps, etc. For the upper extremities, plyometics would include airborne push-ups, throwing and catching a medicine ball against a mini trampoline, etc.

In essence, stretch shortening may be trained by any mechanism that can rapidly convert an eccentric to a concentric contraction. This includes the use of isotonic, isokinetic, motorized hydraulic or pneumatic, and elastic resistance (e.g., elastic bands, bendable rods, springs, etc.) devices. The simplest way to train stretch shortening involves the use of dumbbells or barbells. When a weight is lifted up against gravity the muscle acting on the weight is undergoing a concentric contraction. Then when the weight is coming down, an eccentric contraction absorbs or slows this downward force. Allowing the weight to fall and rapidly converting this to an upward motion of the weight will train stretch shortening.

The use of dumbbells in this way is effective only in combination with

complete isolation and stabilization of surrounding body parts. For a better understanding of stabilization, resistance-training techniques are divided into linear and rotary motions. Linear motions are those that involve a back and forth movement of a limb or the body, examples of which include bench press, military press and squat thrusts. These types of lifting motions require more than one muscle group and at least two joints. Stabilization of surrounding body parts is easily accomplished by pressing the body or legs against an immovable object. This would include the use of a padded bench or chair in the case of bench press and military press exercises and the use of the ground in the case of squat thrusts.

Rotating types of motions involve moving a limb around an axis of rotation, examples of which include arm curls, leg curls and leg extensions. Rotary motion utilizes one muscle group that acts around one specific joint, rather than the multi-joint motions that are necessary for linear motions. Stabilization of a single joint performing a rotary exercise through an arc of motion requires 3-point isolation and stabilization for optimal stability. In one embodiment, the first contact point is where the actuator meets the limb being trained distal to the axis of rotation of the joint. The actuator delivers the force to the limb or body part. The second contact point is where a support pad meets the athlete's body at or near the axis of rotation on the opposite side of the limb as the first contact point. The third contact point is where a support pad meets the athlete's body proximal the axis of rotation and on the same side of the limb as the first contact point. The neck and lumbar muscles, although they do not act at a single joint, the spine segments do combine their actions to form an isolated "joint"-like motion (they flex and extend) and thus can be stabilized in accordance with the above principles. Finally, the center of rotation of the joint being trained and the actuator axle need to be co-axially aligned.

In one embodiment, moving weights with gravity is used to train stretch shortening because it meets the requirements for eccentric to concentric conversion, it is simple to apply and is cost effective. The use of an apparatus that

isolates and stabilizes each joint is required. Although a weight stack device may be used to train this type of contraction, the increased friction in the pulleys and weight stabilizing poles for cable-pulley mechanisms and the increased friction with multiple bearings in the direct drive mechanisms slows the downward movement of the weight stack, resulting in a decreased eccentric load relative to the concentric load. An apparatus using plate loading weights is the preferred type of device to train stretch shortening because the single rotating bearing at the actuator axis has less friction than these other mechanisms, giving better eccentric and stretch shortening training.

Figures 1A through 6D depict various 3-point contact systems for the major joints and both spinal segments. The small arrows indicate the direction and location of each of the contact points discussed above needed to obtain 3-point isolation and stabilization around the desired joint. As used herein, "contact point" refers to a force vector indicating both the location and the direction of a force applied to the athlete. The larger arrows indicate the direction of limb movement in opposition to the resistance of the actuator. Note that some points are best secured by a strap, others by a padded structure and some by either one.

Figure 1A illustrates wrist stabilization system 20A for (palmar) flexion. First contact point 22A is located where the actuator 24A engages with the limb 26A being trained distal to the axis of rotation 28A of the joint. The axis of rotation 28A is located at the wrist joint. The actuator 24A provides resistance in the direction 24A as the wrist is moved in the direction 32A. The second contact point 34A is support pad located at or near the axis of rotation 28A of the joint, but on the opposite side of the limb 26A as the first contact point 22A. The third contact point 36A is support pad located proximal the axis of rotation 28A and on the same side of the limb 26A as the first contact point 22A. The support pad 36A may optionally include a strap 38A to further secure the limb being trained.

Figure 1B illustrates wrist stabilization system 20B for extension

(dorsiflexion). First contact point 22B is located where the actuator 24B engages with the wrist 26B being trained distal to the axis of rotation 28B of the joint. The axis of rotation 28B is located at the wrist joint. The actuator 24B provides resistance in the direction 22B as the wrist is moved in the direction 32B. The second contact point 34B is support pad located at or near the axis of rotation 28B of the joint, but on the opposite side of the limb 26B as the first contact point 22B. The third contact point 36B is support pad located proximal the axis of rotation 28B and on the same side of the limb 26B as the first contact point 22B. The support pad 36B may optionally include a strap 38B to further secure the limb being trained.

Figure 1C illustrates elbow stabilization system 20C for flexion. First contact point 22C is located where the actuator 24C engages with the arm 26C being trained distal to the axis of rotation 28C of the joint. The axis of rotation 28C is located at the elbow joint. The actuator 24C provides resistance in the direction 22C as the forearm is moved in the direction 32C. The second contact point 34C is support pad located at or near the axis of rotation 28C of the joint, but on the opposite side of the limb 26C as the first contact point 22C. The third contact point 36C is a support pad located proximal the axis of rotation 28C and on the same side of the limb 26C as the first contact point 22C. The support pad 36C may optionally include a strap 38C to further secure the limb 26C being trained.

Figure 1D illustrates elbow stabilization system 20D for extension. First contact point 22D is located where the actuator 24D engages with the arm 26D being trained distal to the axis of rotation 28D of the joint. The axis of rotation 28D is located at the elbow joint. The actuator 24D provides resistance in the direction 22D as the forearm is moved in the direction 32D. The second contact point 34D is support pad located at or near the axis of rotation 28D of the joint, but on the opposite side of the limb 26D as the first contact point 22D. The third contact point 36D is located proximal the axis of rotation 28D and on the same side of the limb 26D as the first contact point 22D. The third contact point 36D can be any of a

variety of devices to secure the shoulder, such as a support pad, a shoulder strap, and the like.

Figure 2A illustrates shoulder stabilization system 50A for contraction. First contact point 52A is located where the actuator 54A engages with the arm 56A being trained distal to the axis of rotation 58A of the joint. The axis of rotation 58A is located at the shoulder joint. The actuator 54A provides resistance in the direction 52A as the arm is moved in the direction 62A. The second contact point 64A is support pad located at or near the axis of rotation 58A of the joint, but on the opposite side of the limb 56A as the first contact point 52A. The third contact point 66A is support pad located proximal the axis of rotation 58A and on the same side of the limb 56A as the first contact point 52A. The pad at the third contact point 66A is preferably engaged with the more firm bone of the front wings one on each side of the pelvis, rather than just the soft abdominal muscle alone.

Figure 2B illustrates shoulder stabilization system 50B for extension. First contact point 52B is located where the actuator 54B engages with the arm 56B being trained distal to the axis of rotation 58B of the joint. The axis of rotation 58B is located at the shoulder joint. The actuator 54B provides resistance in the direction 52B as the arm is moved in the direction 62B. The second contact point 64B is support pad located at or near the axis of rotation 58B of the joint, but on the opposite side of the limb 56B as the first contact point 52B. The third contact 66B point is support pad located proximal the axis of rotation 58B and on the same side of the limb 56B as the first contact point 52B for the actuator 54B. The shoulder stabilization system 50B may optionally include a waist strap 68B to further secure the athlete being trained.

Figure 3A illustrates ankle stabilization system 120A for flexion. First contact point 122A is located where the actuator 124A engages with the foot 126A being trained distal to the axis of rotation 128A of the joint. The axis of rotation 128A is located at the ankle joint. The actuator 124A provides resistance in

the direction 122A as the ankle is moved in the direction 132A. The second contact point 134A is support pad located at or near the axis of rotation 128A of the joint, but on the opposite side of the limb 126A as the first contact point 122A. The third contact point 136A is support pad located proximal the axis of rotation 128A and on the same side of the limb 126A as the first contact point 122A. The support pad 136A may optionally include a strap 138A to further secure the limb being trained.

Figure 3B illustrates ankle stabilization system 120B for extension. First contact point 122B is located where the actuator 124B engages with the foot 126B being trained distal to the axis of rotation 128B of the joint. The axis of rotation 128B is located at the ankle. The actuator 124B provides resistance in the direction 122B as the ankle is moved in the direction 132B. The second contact point 134B is support pad located at or near the axis of rotation 128B of the joint, but on the opposite side of the limb 126B as the first contact point 122B. The third contact point 136B is support pad located proximal the axis of rotation 128B and on the same side of the limb 126B as the first contact point 122B. The support pad 134B may optionally include a strap 138B to further secure the limb being trained.

Figure 4A illustrates knee stabilization system 150A for exercising the quadriceps muscles for knee extension while in the seated position. First contact point 152A is located where the actuator 154A engages with the leg 156A being trained distal to the axis of rotation 158A of the joint. The axis of rotation 158A is located at the knee. The actuator 154A provides resistance in the direction 152A as the calf is moved in the direction 162A. The second contact point 164A is support pad located at or near the axis of rotation 158A of the joint, but on the opposite side of the limb 156A as the first contact point 152A. The third contact point 166A is support pad located proximal the axis of rotation 158A and on the same side of the limb 156A as the first contact point 152A. The knee stabilization system 150A may optionally include a waist strap 168A to further secure the athlete being trained. Isolation and stabilization by the waist strap 168A at the lower abdomen is best

accomplished if the pad or strap actually contacts the more firm bone of the front wings, one on each side, of the pelvis or the upper end of the femur, rather than just the soft abdominal muscle alone.

Figure 4B illustrates knee stabilization system 150B for exercising the hamstrings muscles for knee flexion while in the seated position. First contact point 152B is located where the actuator 154B engages with the leg 156B being trained distal to the axis of rotation 158B of the joint. The axis of rotation 158B is located at the knee. The actuator 154B provides resistance in the direction 152B as the arm is moved in the direction 162B. The second contact point 164B is one or both of the support pad located at or near the axis of rotation 158B of the joint, but on the opposite side of the limb 156B as the first contact point 152B. The support pad 164B can be located above or below the patella to avoid patellar problems that may occur with direct pressure on it. Appropriate stabilization is rendered by fixing the upper thigh/hip joint, rather than the waist. The third contact point 166B is support pad located proximal the axis of rotation 158B is located on the same side of the limb 156B as the first contact point 152B. The knee stabilization system 150B may optionally include a waist strap to further secure the athlete being trained.

Figure 4C illustrates knee stabilization system 150C for exercising the quadriceps muscles for knee extension from a standing position. First contact point 152C is located where the actuator 154C engages with the leg 156C being trained distal to the axis of rotation 158C of the joint. The axis of rotation 158C is located at the knee. The actuator 154C provides resistance in the direction 152C as the calf is moved in the direction 162C. The second contact point 164C is support pad located at or near the axis of rotation 158C of the joint, but on the opposite side of the limb 156C as the first contact point 152C. The third contact point 166C is support pad located at the proximal femur and/or anterior pelvic wing proximal the axis of rotation 158C and on the same side of the limb 156C as the first contact point 152C. The knee stabilization system 150C may optionally include a waist strap

168C to further secure the athlete being trained.

Figure 4D illustrates knee stabilization system 150D for exercising the hamstrings muscles for knee flexion from a standing position. First contact point 152D is located where the actuator 154D engages with the limb 156D being trained distal to the axis of rotation 158D of the joint. The axis of rotation 158D is located at the knee. The actuator 154D provides resistance in the direction 152D as the arm is moved in the direction 162D. The second contact point is support pad 164D located at or near the axis of rotation 158D of the joint, but on the opposite side of the limb 156D as the first contact point 152D. The third contact point is support pad 166D located at the proximal femur where actual contact is made with the back of the pelvis anywhere from its lower end (ischial tuberosity) to its upper end (top of the posterior iliac wing and sacrum) proximal the axis of rotation 158D and on the same side of the limb 156D as the first contact point 152D. By turning the athlete 90 degrees, the stabilization system 150C and 150D of Figures 4C and 4D may be used to strengthen hip abduction and adduction.

Figures 4E and 4F illustrate hip flexion stabilization systems 150E, 150F while in a standing position. First contact points 152E, 152F are located where the actuators 154E, 154F engage with the legs 156E, 156F being trained distal to the axes of rotation 158E, 158F of the joints. The axes of rotation 158E, 158F are located at the hips. The actuators 154E, 154F provide resistance in the directions 152E, 152F as the legs are moved in the directions 162E, 162F. The second contact points 164E, 164F are support pads located at or near the axes of rotation 158E, 158F of the joints, but on the opposite side of the limbs 156E, 156F as the first contact points 152E, 152F. The third contact points 166E, 166F are support pads located proximal the axes of rotation 158E, 158F and on the same side of the legs 156E, 156F as the first contact points 152E, 152F. The knee stabilization systems 150E, 150F may optionally include waist straps 168E, 168F to further secure the athletes being trained. By turning the body 90 degrees, the stabilization systems

150E, 150F may be used for hip extension stabilization as illustrated in Figures 4G and 4H.

Figures 4G and 4H illustrate hip flexion stabilization systems 150G, 150H while in a standing position. First contact points 152G, 152H are located where the actuators 154G, 154H engage with the legs 156G, 156H being trained distal to the axes of rotation 158G, 158H of the joints. As for hip flexion, contact may be above or below the knee. The axes of rotation 158G, 158H are located at the hips. The actuators 154G, 154H provide resistance in the directions 152G, 152H as the legs are moved in the directions 162G, 162H. The second contact points 164G, 164H are support pads located at or near the axes of rotation 158G, 158H of the joints, but on the opposite side of the limbs 156G, 156H as the first contact points 152G, 152H. The third contact points 166G, 166H are support pads located proximal the axes of rotation 158G, 158H and on the same side of the legs 156G, 156H as the first contact points 152G, 152H. The knee stabilization systems 150G, 150H may optionally include waist straps 168G, 168H to further secure the athletes being trained. By turning the body 90 degrees, the stabilization systems 150G, 150H may be used for hip extension stabilization as illustrated in Figures 4E and 4F.

Figure 5A illustrates neck stabilization system 220A for flexion. First contact point 222A is located where the actuator 224A engages with the head 226A being trained distal to the axis of rotation 228A of the joint. The axis of rotation 228A is located at the neck. The actuator 224A provides resistance in the direction 222A as the neck is moved in the direction 232A. The second contact point 234A is support pad located at or near the axis of rotation 228A of the joint, but on the opposite side of the head 226A as the first contact point 222A. The third contact point 236A is support pad located near the lower ribs/upper abdominal area, rather than the waist, such that lumbar spine flexion is avoided when training the neck. A pad only at the waist would allow simultaneous neck and abdominal flexion that is not optimal when complete isolation is preferred. The stabilization system 220A

may optionally include a strap 238A to further secure the limb being trained.

Figure 5B illustrates neck stabilization system 220B for extension. First contact point 222B is located where the actuator 224B engages with the head 226B being trained distal to the axis of rotation 228B of the joint. The axis of rotation 228B is located at the neck. The actuator 224B provides resistance in the direction 222B as the head 226B wrist is moved in the direction 232B. The second contact point 234B is support pad located at or near the axis of rotation 228B of the neck, but on the opposite side of the limb 226B as the first contact point 222B. The third contact point 236B is a support pad located proximal the axis of rotation 228B and on the same side of the head 226B as the first contact point 222B. A shoulder harness 238B may optionally be included to further stabilize the athlete.

Figure 6A illustrates stabilization system 250A for abdominal flexion training in a sitting position. Figure 6B shows a similar stabilization system for the abdominal muscles in a standing position. The reference numbers used are the same except for the letter suffix, although the contact points may vary slightly. An important concept for abdominal flexion isolation is that the hip flexor muscles need to be excluded. Prior art that places a pad or strap around the thighs or legs does not exclude the hip flexors. In order to isolate completely the abdominal muscles requires that the stabilization occurs at the pelvis, or, more precisely, the anterior spines of the wings of the pelvis. First contact point 252A is located where the actuator 254A engages with the torso 256A distal to the axis of rotation 258A of the abdominal muscles. The axis of rotation 258A is located at the waist. The actuator 254A provides resistance in the direction 252A as the torso is moved in the direction 262A. The second contact point 264A is support pad located at or near the axis of rotation 258A, but on the opposite side of the torso 256A as the first contact point 252A. The third contact point 266A is support pad located proximal the axis of rotation 258A and on the same side of the torso 256A as the first contact point 252A. The abdominal stabilization system 250A may optionally include a waist strap 268A

to further secure the athlete being trained. Isolation and stabilization by the waist strap 268A at the lower abdomen is best accomplished if the pad or strap actually contacts the more firm bone of the front wings, one on each side, of the pelvis, rather than just the soft abdominal muscle alone.

Figure 6C illustrates stabilization system 250C for back extension in a sitting position. Figure 6D shows the stabilization system 250D used for the abdominal muscles in a standing position. The reference numbers used are the same except for the letter suffix, although the contact points may vary slightly. First contact point 252A is located where the actuator 254A engaged with the torso 256A distal to the axis of rotation 258A of the abdominal muscles. The axis of rotation 258A is located at the waist. The actuator 254A provides resistance in the direction 252A as the torso is moved in the direction 262A. The second contact point 264C is support pad located at or near the axis of rotation 258A, but on the opposite side of the torso 256A as the first contact point 252A. The third contact point 266C is support pad located in the sacrum/pelvis area, rather than at the upper thigh, proximal the axis of rotation 258A and on the same side of the torso 256A as the first contact point 252A. The abdominal stabilization system 250A may optionally include a waist strap to further secure the athlete being trained.

Figures 7A-7F illustrate six different configurations for attaching a hydraulic unit to an exercising apparatus in order to obtain this type of resistance for training for acceleration. In Figure 7A, one or more hydraulic resistance units 300 are attached to the actuator arm 302 on the same side of the axis of rotation 304 as the athlete 306 for linear types of exercises in either the compression or the tension mode. In Figure 7B, the hydraulic resistance units 300 are on the opposite side of the axis of rotation 304 as the athlete (not shown) for a linear type of exercise, in either the compression or the tension mode. In Figure 7C, the hydraulic resistance units 300 are located in line with movement of a limb 308 for exercising an isolated joint in a rotating type of exercise in either the compression or the tension mode. In

Figure 7D, the hydraulic resistance unit 300 is attached to a lever 310 that extends from the rotating actuator 302 at axle 312 for use in either the compression or the tension mode. In Figure 7E, the hydraulic resistance unit 300 is attached in either parallel or series with a weight stack 314. In Figure 7F, the actuator arm 302 is attached to a circular hydraulic resistance unit 316. One or more valves 318 are provided on the circular hydraulic resistance unit 316 to vary resistance. The present invention contemplates attaching the hydraulic resistance device 300 or 316 to any existing weight loading apparatus using one of the six mechanisms discussed above.

Figures 8-13 are directed to an exercise device for training hip flexion and extension in accordance with the present invention. Figure 8 illustrates a base frame 401 with two sections. One section is roughly a square and has a standing platform 402. The second section is a rectangular shaped area separated from the standing platform 402 by an inverted V-frame 403. Attached to this V-frame 403 is a three-sided rectangular shaped frame 404. The frame 404 may be converted to a four-sided one if the connecting bar 405 is included. When the athlete stands on the platform 402, he is stabilized by the frame 404 or 405. There are four handles 406 for grasping onto. On each side, between the front and back handles one may place a forearm pad 407 (see Figure 11).

With respect to the three points of-isolation and stabilization system, as discussed above, the first contact point is the contact point of the distal limb to the pad 416 of the actuator arm 417. The pad 416 can slide along the arm 417 by a telescoping tube mechanism 418. The actuator arm 417 attaches to the rotary actuator 419, which has multiple holes for pin-in-hole setting of the actuator arm's 417 starting position. The rotary actuator 419 attaches to the inverted V 403 frame through its axle 420. The axle 420 attaches to a cross-bar between vertical arms of the V frame 403, by a ball-bearing mechanism, (not shown in the drawings).

The second contact point is either the lower back at the sacrum (for hip flexion training) or the front of the pelvis (for hip extension training). This is

depicted by pad 408. To allow for horizontal and vertical adjustment, in order to align properly the hip, there are both horizontal 409 and vertical 410 sliding bars with pin-in-hole settings.

The third contact point of stabilization is depicted by pad 411, which is attached to the frame 404 by virtue of a horizontal bar 412. Similar to bars 409 and 410 for pad 408, the horizontal 412 and vertical 413 bars for pad 411 have sliding characteristics for adjustment with pin-in-hole settings. Further positioning of the user is provided by vertical adjustment control of the standing platform. This consists of pneumatic cylinders 414 on each side along with a pin-in-hole mechanism having multiple settings 415 (See Figure 13), to allow for a wide variety of user heights.

On the other side of the V frame 403, the axle 420 is attached to the weight bearing lever arm 421 (see Figure 10), where a perpendicular rod placed distally 422 accepts weighted plates 423. These plates are stabilized at their starting position, which is directly downward, by a stop mechanism 424. This can be moved onto either side of the weight plate, depending on the direction of movement of the weights (the mechanism for moving the stop mechanism 424 is not shown in the drawings).

A hydraulic cylinder 425 is attached to the rotary actuator axle 420 by its piston 426. The piston 426 attaches to the axle 420, either through a separate lever 427 (see Figure 9 and 12) or to an extension of the weight plate attachment 428, which is depicted in Figure 10. The cylinder 425 attaches to the V frame by a mechanism that allows limitless flexion/extension or sideways motion at the attachment site 429. Figures 8, 9 and 10, as demonstrated, suggest that the athlete faces only one direction when training in the apparatus, forward.

The embodiment of Figures 8-13 includes several options: (1) a separate apparatus each for right hip flexion, left hip flexion, right hip extension and left hip extension; (2) a separate apparatuses for right hip flexion and left hip

extension, and a mirror-image one for the opposite motions; (3) an apparatus as in Figure 10 where right or left hip flexion can be trained on one apparatus; and (4) one unit that is able to train all four motions, bilateral hip flexion and extension. A second apparatus can optionally be made solely for right and left hip extension. These last two options require mirror image weight bearing and hydraulic units as in figure 10. The "left" side, if completed in Figure 8, would consist of the dotted-line inverted V frame 430, to which would attach a mirror image of all of the R sided elements that are connected to the V frame 403. Finally, a rotary hydraulic actuator may be attached to the actuator axle in place of the hydraulic cylincer.

Figure 14 schematically depicts an alternate stabilization system 500 for hip and knee strengthening. Upper torso stabilization pad 502 and lower torso stabilization pad 503 are mounted on isolation frame 501. In the illustrated embodiment, the resistance mechanism is a set of weights 504 attached to waste belt 505 by a hinged axis 506. As illustrated, the hip flexors are being trained. By turning the athlete 180 degrees and shifting the weights, appropriate hip extension may also be trained.

Figure 15 schematically depicts a frame 601 where an athlete is in a semi-prone position. An ankle weight 602 is used for resistance. Alternatively, a weight can be attached to the thigh of the athlete using the waist belt 505 of Figure 14. Stabilization is provided by a torso pad 603 with a rounded edge 604 as the second fixation point. An upper torso pad 605 attached to the frame 601 provides the third fixation point. Alternatively, the athlete can turn around in a semi-prone position in order to train the hip flexors.

Figures 16 and 17 schematically illustrate a sectorized weight stack resistance mechanism 650 for upright knee extension and upright knee flexion training, respectively. The three point stabilization system is substantially as shown in Figures 4C and 4D. The standing platform 652 has vertical adjustment capabilities to center the axis of rotation of the knee 654 with the axis of rotation of

the actuator 656. Alternatively, the standing platform 652 may be stationary with vertical adjustment capabilities at the actuator 656.

Use of the Hip Flexion/Extension Device

Biomechanical analysis demonstrates that the primary muscles functioning in the horizontal component of running (forward propulsion) are the hip flexors (iliopsoas and rectus femoris), in association with hip extensors (gluteus maximus and hamstrings). The hip flexors in close association with the hip extensors are the major muscles that cause forward propulsion. To run faster, forward propulsion needs to be improved. Hence, the primary focus in training is placed on these muscle groups, especially the hip flexors. Due to a necessity to maintain muscle balance, the hip extensors are felt to be equally important in training.

The modes of contraction that need to be focused on for training these muscles are concentric (acceleration and power) and the eccentric-concentric conversion (stretch-shortening cycle). These two modes are of primary consideration because running is really a series of accelerations and decelerations. Concentric training for power improves forward acceleration of limbs. Training the stretch-shortening cycle gives muscles the capability of decelerating the rapid limb movement caused by the concentric contraction. Furthermore, training the stretch-shortening cycle in rapid fashion trains the muscles to absorb energy during the stretch phase in order to be released immediately in the subsequent concentric phase.

In order to understand better the present method and apparatus, two concepts defined above are stressed 1) supramaximal training and 2) sport specificity. Supramaximal training is of the utmost importance because it is the only way that a well-trained athlete can hope to improve performance. Supramaximal training involves stressing muscles that are involved in a certain activity above and

beyond the demands normally placed on them during that activity. To obtain the optimal benefit from supramaximal training, muscles and/or body movements must be isolated. Only when isolated can the athlete place maximum focus on that muscle. Finally, it is well known that the acidic state which occurs intracellularly in muscles undergoing intense activity leads to impaired contracitility, hence fatigue. Supramaximal training enhances a muscle's buffering capacity, thus prolonging time to fatigue. This type of training adapts the muscle in a way that improves its ability to exercise despite low intracellular pH.

Sport specific means exercising muscles in a way that they are used during a particular activity, such that runners run, swimmers swim, etc. For runners, sports specific training refers to a stride appropriate for the distance of the event or a motion that simulates the appropriate stride. The opposite of sport specific training is crosstraining. Although there is a place for crosstraining in an athlete's overall program, crosstraining will not improve a well-trained athlete's performance in the target event. The training method of the present invention is a running specific weight training method.

In order to train supramaximally, the muscles involved must be completely isolated and the rest of the body must be completely stabilized. By completely isolating the hip joint and completely stabilizing the torso, the present apparatus allows these muscles to be trained supramaximally. Supramaximal training is absolutely necessary when the goal is to optimize strength gains, especially if the athlete has plateaued. The present apparatus fully stabilizes the torso in an upright fashion with a three point stabilization system. For training the hip abductors and hip adductors, the athlete's body is turned 90° with respect to the horizontal component training apparatus.

The training device of Figures 8-13 has the ability to isolate hip flexors and extensors (as well as the hip abductors and hip adductors) in the upright position while stabilizing the torso using a three point stabilization system and the

ability to train with either isotonic or hydraulic resistance, or both. This combination of features permits supramaximal training of the hip muscles. In the preferred embodiment, training the stretch-shortening cycle is done isotonically and training for acceleration (and power) is done using hydraulic resistance.

Muscles involved in the vertical component are the quadriceps and calf (gastrocnemius and soleus) muscles. These muscles contract in an eccentric fashion at ground contact to absorb ground reaction forces. The quadriceps are the muscles which have received the greatest amount of attention in the literature. From a biomechanic viewpoint, in the vertical plane of running, the two muscle groups (quadriceps and calf muscles) function simultaneously. If too much focus is placed on the quadriceps over the calf muscles, an imbalance will develop. For example, overtraining the quadriceps gives rise to an increased incidence of hamstring injuries. Similarly, overtraining the quadriceps over the calf muscles gives rise to increased injuries. Since the Achilles tendon plays a significant role in force absorption and release in conjunction with the calf muscles, one cause for the relatively high incidence of Achilles injuries in sprinting (i.e. tendonitis) may be the result of overtraining the quadriceps relative to the calf muscles. A device for training the vertical component is disclosed in co-pending U.S. Patent Serial No. 09/435,220 filed November 5, 1999, entitled “Run Specific Training Method and Apparatus.”

The number of repetitions done by the athlete is determined by which race is to be run. For example, a 100 meter sprinter would perform 15 - 20 repetitions (a sprinter, once at full speed, takes 3 - 4 steps per 10 meters distance, thus each leg goes through 15-20 cycles in a 100 meter race) as rapidly as possible for both resistance mechanisms. Instead of counting repetitions, the athlete can also train based on expected time for a race. For example, a 100 meter sprinter trains as rapidly as possible for 10 - 12 seconds and a 400 meter sprinter trains for 50 to 60 seconds, although some pacing would be needed here.

The starting position for both training types should be varied. For hip flexion strengthening, a sprinter should concentrate on performing these exercises with relatively less total hip extension (i.e., less than zero degrees extension (zero is when the leg is completely vertical) because we know that the elite sprinter runs a race with hip range of motion of about 20 degrees to about 90 degrees. For hip extension training, the starting point should approximate 90 degrees of flexion, as this is the amount of flexion that occurs with sprinting. Also for hip extension training with both calf and thigh pad resistance should be done in order to include lower hamstrings training.

All patents and patent applications disclosed herein, including those set forth in the Background of the Invention, are hereby incorporated by reference. Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. In addition, the invention is not to be taken as limited to all of the details thereof as modifications and variations thereof may be made without departing from the spirit or scope of the invention.